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THE TRACTOR AND ITS EFFECTS ON FARMING IN MINNESOTA

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Truman R. Nodland and G. A. Pond, Minnesota Agricultural Experiment Station

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INTRODUCTION

More than 86,000 tractors were used on Minnesota farms in 1938. This was more than three times the number used in 1925 (table 1). During this period, horse-and-mule numbers decreased from 851,000 to 695,000 -- a decline of 20 percent. The change in form of farm power is greater than suggested by trends in tractor and horse-and-mule numbers because an increasing proportion of the tractors have been of the all-purpose type. Equipment has been designed for use with the all-purpose tractors and, accordingly, has facilitated their use in a large variety of operations.

1/ Assistance in the preparation of these materials was furnished by the personnel of the Work Projects Administration, Official Project No. 65-1-71-140, Subproject No. 461; Sponsor, University of Minnesota.

Table 1. — Horses, mules, and tractors on Minnesota farms, 1925-38

Year	Horses and Mules January 1 1/	Tractors
	Number	Number
1925	851,000	2/ 25,600
1926	840,000	3/ 28,440
1927	833,000	2/ 33,400
1928	824,000	3/ 36,650
1929	801,000	2/ 40,800
1930	822,000	4/ 48,457
1931	805,000	2/ 47,500
1932	789,000	3/ 48,100
1933	774,000	3/ 50,100
1934	765,000	3/ 53,300
1935	759,000	3/ 63,900
1936	737,000	3/ 69,700
1937	737,000	3/ 80,700
1938	695,000	5/ 86,288

1/ Kirk, Paul H., Minnesota Crop and Livestock Statistics, Minnesota Dept. of Agriculture Bulletins 55,63, 5, 24, 28, 30.
2/ Kirk, Paul H., Minnesota State Farm Census, Minnesota State Dept. of Agriculture Bulletins 46, 61, 3, 8, adjusted to U. S. Federal Census level.
3/ Estimates from trend in number of tractors on farms interviewed.
4/ United States Census, 1930.
5/ Estimates from Implement and Tractor Implement Trade Journal Company, Kansas City, August 6, 1938.

PURPOSES OF STUDY

This study had several purposes. The organization of mechanized farms in different areas of Minnesota was to be observed. At the same time the observers were to ascertain the extent to which workstock has been displaced by tractors, to examine changes that have occurred in livestock and crop enterprises following mechanization, to investigate modifications in farm size that have been associated with the introduction of tractors, and to determine changes that have taken place in labor requirements. Changes may have occurred that are not entirely caused by the use of tractor power, but an analysis of these changes and an evaluation of the extent to which the tractor has been responsible will provide a background for those who are considering the possible effects on farm organization in the future.

METHODS OF STUDY

The United States Department of Agriculture and the University of Minnesota made a survey in June 1939 covering 581 farms in five type-of-farming areas of Minnesota. These farms had 709 tractors. Locations of the farms studied are indicated in figure 1; 68 were in the southeastern dairy and livestock area, 84 in the south central dairy area, 161 in the

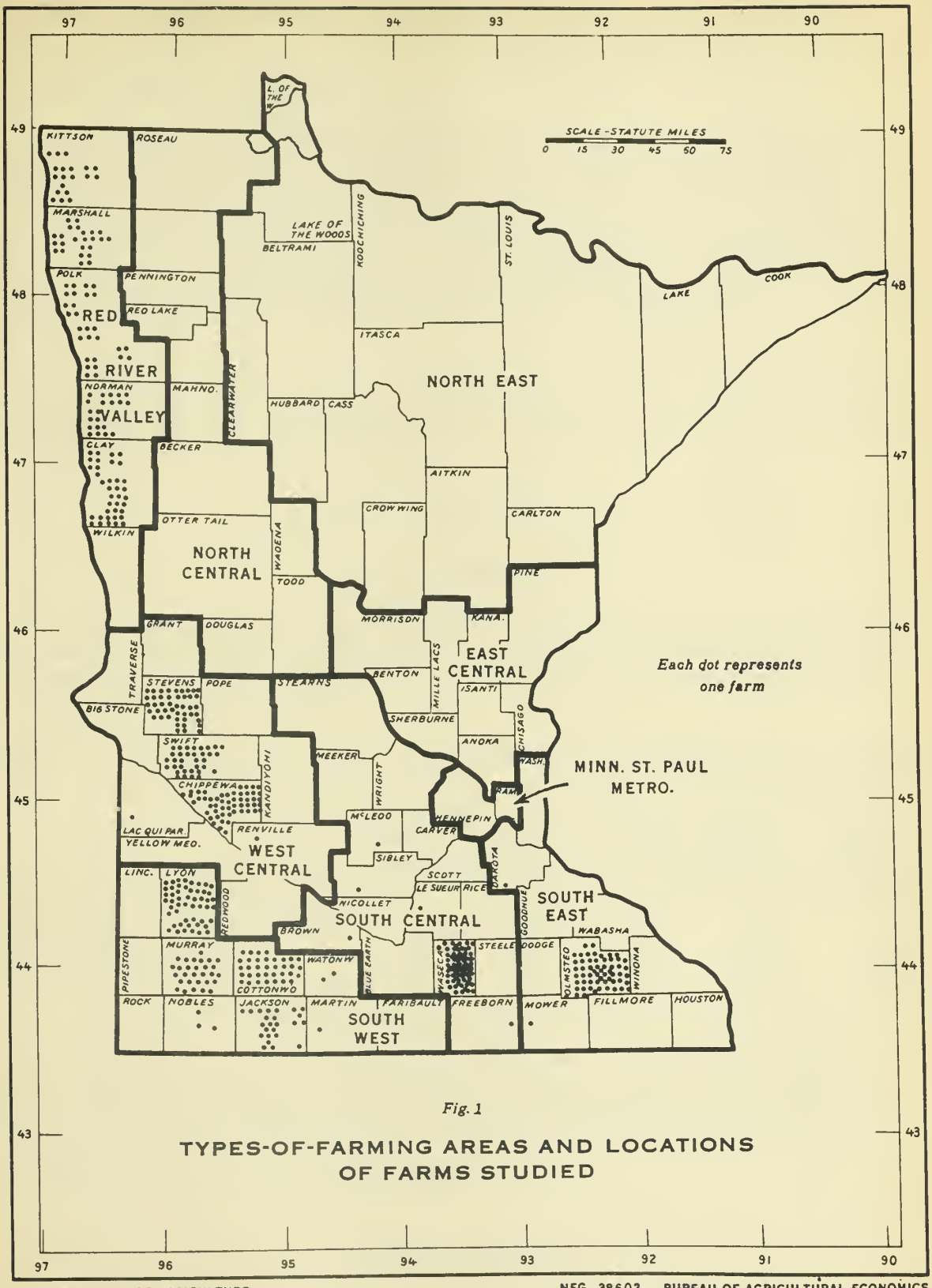

Fig. 1

TYPES-OF-FARMING AREAS AND LOCATIONS OF FARMS STUDIED

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southwestern livestock and cash grain area, 139 in the west central cash grain and livestock area, and 129 in the Red River Valley small grain, potato, and livestock area. Only farms on which a tractor had been in use at least 1 year were selected.

The survey record included information on the crop and livestock organization for the year ending April 1, 1939 and for the year before the purchase of the first tractor. Information was also secured relative to the machinery and equipment used with tractors and the hours tractors were used. Considerable supplementary information was gained on farm hauling, labor, practices used in tractor and horse operation, and methods used by farmers to finance the purchase of tractors. The data pertaining to changes in farm organization were used as bases for this report. 2/

2/ The additional data have been analyzed and presented in the processed report called "The Use of Farm Tractors in Minnesota" by Truman R. Nodland, A. J. Schwantes, and Ross V. Baumann.

FARM ORGANIZATION

Size of Farms

The farms studied were somewhat larger than the average of all farms in the same area. Those in southeastern Minnesota and south central Minnesota were more than 40 percent larger, and those in the Red River Valley were about 85 percent larger.

Table 2. — Size of tractor farms studied and size of all farms by areas 1/

Item	Area				
	South East	South Central	South West	West Central	Red River Valley
Farms studied, number	68	84	161	139	129
Acres per farm studied	240	224	278	335	523
Acres per farm, all farms	2/ 170	156	210	238	279

1/ Area averages are computed from county data: South East, Olmstead County, South Central, Waseca County; South West, Cottonwood, Jackson, Lyon, and Murray counties; West Central, Stevens, Swift, and Chippewa Counties; Red River Valley, Kittson, Marshall, Polk, Norman, and Clay Counties.
2/ Minnesota State Farm Census, 1938.

Land Utilization

The utilization of land on the tractor farms varied with the location. Small grain occupied nearly 80 percent of the cropland in the Red River Valley, but less than half of the cropland in southern Minnesota (table 3).

In the South East area, pasture made up almost one-third of the total farm acreage, whereas in the other areas it occupied less than one-fifth.

Table 3. — Utilization of land on the tractor farms

Land Use	Area				
	South East	South Central	South West	West Central	Red River Valley
	Acres per farm studied				
Corn	46	54	78	71	19
Potatoes	1/	1/	1/	1/	16
Other cultivated crops	2	5	1/	2	3
Total cultivated crops	48	59	78	73	38
Wheat	8	14	4	58	168
Oats	31	33	43	56	46
Barley	24	16	34	17	66
Flax	1	3	28	11	15
Other small grains	7	5	4	8	3
Total small grains	71	71	113	150	298
Alfalfa	10	14	12	8	14
Other tame hay	18	9	8	9	23
Wild hay	4	13	6	21	5
Total hay	32	36	26	38	42
Total crops	151	166	217	261	378
Rotation pasture	16	8	10	16	22
Permanent pasture	62	37	31	18	24
Total pasture	78	45	41	34	46
Tillable land not cropped	1	1	3	17	70
Woodland, not pastured, waste, farmstead, etc.	10	12	17	23	29
Total acres in farm	240	224	278	335	523

1/ Less than 0.5 acres.

Livestock

Livestock enterprises were most important in southeastern Minnesota. The farmers there maintained almost twice as many livestock as were kept by farmers in the Red River Valley. There were 39 animal units per farm in southeastern Minnesota and only 22 in the Red River Valley (table 4). Cows were kept for milk on all but 15 of the 581 farms studied. Dairying is more important in southern Minnesota. Beef cattle and hogs are found in greater numbers in central Minnesota.

Table 4. — Productive livestock other than poultry on tractor farms by areas

Kinds of livestock	Area				
	South East	South Central	South West	West Central	Red River Valley
	Numbers per farm				
Dairy cows	16	15	8	9	8
Other dairy cattle	11	11	4	9	10
Beef cows	2	1	3	1	2
Other beef cattle	13	3	12	3	3
Brood sows	8	10	11	7	2
Ewes 1/	12	7	9	11	13
Total animal units	39	32	31	23	22
Animal units per 100 A.	17	15	12	8	5

1/ One animal unit of livestock is equal to 1 mature horse or 1 mature cow, 2 colts, 2 young cattle, 5 hogs, 10 pigs, 7 sheep, or 14 lambs.

Power and Machinery

Tractor power constituted about 70 percent of the potential power available on farms using tractors (table 5). The proportion varied from approximately 68 percent in the South Central area to about 77 percent in the Red River Valley. The variation in the proportion of the total power available in the form of workstock and tractors occurred because of differences in the number of workstock and the drawbar rating of tractors used on the farms. The West Central area had an average of 3.7 horses per farm and the South Central area 4.7. Tractor drawbar horsepower per farm ranged from an average of 15.1 in the West Central area to 23.7 in the Red River Valley. The variation from farm to farm was, of course, greater.

Table 5. — Drawbar power available on tractor farms

Item	Unit	Area				
		South East	South Central	South West	West Central	Red River Valley
Horses and mules per farm	Number	4.1	4.7	4.1	3.7	4.3
Tractor drawbar power 1/	Horsepower	15.5	16.6	15.2	15.1	23.7
Tractor drawbar power	Horse Equivalent 2/	9.3	10.0	9.1	9.1	14.2
Total farm power	Horse Equivalent	13.4	14.7	13.2	12.8	18.5
Proportion of total farm power supplied by tractors	Percent	69.4	68.0	68.9	71.1	76.8

1/ Only tractors used for field work were included. Tractor drawbar power based on the Nebraska tractor tests.
2/ To secure "horse equivalent" the tractor drawbar horsepower rating was multiplied by 0.6.

Approximately three-fourths of the tractors were of the all-purpose type, that is, they were adapted for use with row crops. Fifty percent of the tractors in the South East area and in the Red River Valley were all-purpose. The proportion of all-purpose tractors was larger in the other areas, because of the larger acreages of row crops and because many of the tractors in these areas had been bought only recently.

Table 6. — Number and type of tractors on tractor farms

Item	Unit	Area					
		South East	South Central	South West	West Central	Red River Valley	All Areas
Tractors	Number	79	101	182	157	190	709
All-purpose tractors	Percent	56	72	84	86	52	71

The farms on which the first tractor purchases were made between 1925-29 averaged larger in size at the time of the tractor purchase than those on which such purchases were made at a later date. Tractors and machinery bought during the latter periods were adapted to a wider variety of operations. The increased number of operations that can be performed by all-purpose tractors together with their smaller size facilitates their use on smaller farms, especially where total power requirements are relatively small.

Table 7. -- Average size of farms at the time of purchase of first tractor, by areas

Area	Period of tractor purchase		
	1925-29	1930-34	1935 and later
	Acres	Acres	Acres
South East	261	204	165
South Central	222	186	181
South West	322	258	236
West Central	280	271	243
Red River Valley	382	403	292

In the Red River Valley, 23 percent of the tractors were purchased prior to 1920. In contrast, only 5 percent of the tractors operated in the South West area were bought before that time. More than 40 percent of the tractors were bought after 1934 in the South West and West Central areas. This was a much larger proportion than in the other three areas.

Table 8. — Periods during which first tractor was bought and percentage of all tractors bought in each period by areas

Period of first tractor purchase	Area				
	South East	South Central	South West	West Central	Red River Valley
	Percent	Percent	Percent	Percent	Percent
1919 and before	16	11	5	12	23
1920-1924	12	15	7	8	16
1925-1929	35	26	22	23	25
1930-1934	13	18	22	15	15
1935 - April 1939	24	30	44	42	21
All periods	100	100	100	100	100

The distributions of tractor corn cultivators, corn pickers, grain drills, and grain combines are shown by size of farm in table 9. Eighty percent of the farms in the five areas were less than 440 acres in size. This group of farms had 82 percent of the corn cultivators, 69 percent of the corn pickers, 50 percent of the grain drills, and 44 percent of the grain combines. Of these machines the tractor corn cultivator was the only one that was distributed evenly over farms of all sizes. The use of the other machines was confined more to the larger farms.

CHANGES IN FARM ORGANIZATION ACCOMPANYING THE ADOPTION OF TRACTORS

The tractor affects farm organization directly when it replaces power furnished by horses, or when it is an addition to total power. In replacing horses, it frees some labor as well as some feed which may be used in producing more livestock. Adjustments may be made in the production of feed crops and cash crops. If the tractor provides additional power, it may enable the operator to farm more land or care for larger numbers of livestock. On the other hand, it may allow more leisure time. The changes that are directly or indirectly attributable to the tractor and mechanized equipment do not appear to be so pronounced on farms included in this study as might be supposed.

Change in Size of Farm

Approximately one-third of the farmers increased the size of their farms after the purchase of a tractor, and 12 percent decreased the size of their units. About 50 percent of the farmers made no change in their acreage (table 10). Farmers in the West Central and Red River Valley areas increased the size of their farms more frequently following the purchase of a tractor than did farmers in the other areas. A part of these changes in size of farm is the result of natural growth in the farm business and probably would have occurred irrespective of the use of tractors.

Table 9. — Relationship between tractor-operated equipment and the size of farms using tractor-operated equipment

Size of farms (acres)	Total farms		Corn cultivators		Corn Pickers		Grain Drills		Grain Combine	
	No.	Percent	No.	Percent	No.	Percent	No.	Percent	No.	Percent
Under 120	16	3	11	3	1	1	1	1	2	5
120 - 199	126	23	77	23	14	16	7	9	5	13
200 - 279	120	22	79	24	18	20	8	10	1	2
280 - 359	127	23	78	24	23	26	16	20	6	15
360 - 439	47	9	26	8	12	14	8	10	4	9
440 - 519	34	6	18	6	7	8	8	10	4	9
520 - 599	25	5	12	4	2	2	10	12	5	13
600 - 679	19	3	8	2	4	5	6	7	4	9
680 - 759	6	1	2	1	1	1	3	4	4	9
760 - 839	5	1	2	1	2	2	4	5		
840 - 919	2						1	1		
920 - 999	2	2	2	1	1	1	1	1		
1000 - 1079	3	1	2	1	1	1	1	1	1	2
1080 - 1159	1		1						1	2
1160 - 1239	2									
1240 - 1319	2		2	1			2	2	1	2
1320 - 1399	2		1				1	1	1	2
1400 - 1479										
1480 - 1559	1		1				1	1	1	2
1560 - over	4	1	2	1	3	3	4	5	3	6
Total	544	100	324	100	89	100	82	100	43	100

Table 10. — Number and percentage of farms on which there had been a change in size since the purchase of the first tractor

Area	Type of change in size					
	Increase in acreage		Decrease in acreage		No change in acreage	
	Number	Percent	Number	Percent	Number	Percent
South East	18	27	16	24	32	49
South Central	17	18	2	2	76	80
South West	41	27	16	10	98	63
West Central	59	45	18	14	54	41
Red River Valley	57	49	13	11	46	40
All areas	192	34	65	12	306	54

Table 11. — Average size of tractor farms before purchase of first tractor and in 1938, by areas

Area	Period when first tractor was bought															
	1923 or before				1924 - 1928				1929 - 1933				1934 - 1937			
	Number of farmers purchasing tractors	Average size of farm before tractor purchase	Average size of farm in 1938	Relative increase in average size of farm	Number of farmers purchasing tractors	Average size of farm before tractor purchase	Average size of farm in 1938	Relative increase in average size of farm	Number of farmers purchasing tractors	Average size of farm before tractor purchase	Average size of farm in 1938	Relative increase in average size of farm	Number of farmers purchasing tractors	Average size of farm before tractor purchase	Average size of farm in 1938	Relative increase in average size of farm
		Acres	Acres	Percent		Acres	Acres	Percent		Acres	Acres	Percent		Acres	Acres	Percent
South East	16	263	267	1.5	22	262	265	1.1	9	205	200	1/ 2.4	17	171	212	24.0
South Central	19	214	236	10.3	17	213	220	3.3	16	235	283	20.4	28	164	190	15.9
South West	12	368	378	2.7	27	266	264	1/ 0.8	40	295	316	7.1	73	235	251	6.8
West Central	20	445	489	9.9	25	291	362	24.4	23	248	289	16.5	52	252	315	25.0
Red River Valley	42	443	672	51.7	28	432	482	11.6	22	398	484	21.6	26	305	416	36.4

1/ Decreases rather than increases.

Changes that occurred in the average size of tractor farms from the time that tractors were first used until 1938 are shown in table 11 for each of the areas. A summary of these changes is shown in table 12. In only two instances the average size of the tractor farms was less in 1938 than it was before the time when the first tractor was obtained. In all the other instances there was an increase in the average size of the tractor farms, but there was no uniformity in the increase, either by area or by period of purchase of the first tractor. The greatest relative increase in average size occurred in the West Central and Red River Valley areas.

Table 12. — Relationship between the time of purchase of the first tractor and change in farm size

Period of purchase of first tractor	Change in size of farm						All farms	
	Increase in farm acreage		Decrease in farm acreage		No change in farm acreage			
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Before 1926	54	41	27	21	51	38	132	100
1926 - 1930	55	38	17	12	72	50	144	100
1931 - 1935	39	33	10	8	70	59	119	100
1936 - 1939	52	34	9	6	91	60	152	100
All periods	200	36	63	12	284	52	1/547	100

1/. Remainder of records were incomplete or farmers had started farming with tractors.

The distribution of tractor farms by size is given in table 28. More farms appear in the larger size classifications in 1938 than before the time when the first tractor was bought.

The relationship between the ownership of certain types of equipment and changes in acreage are pronounced in some cases. Of the farms that increased in size after the purchase of a tractor 24 percent had tractor grain drills, while of those which decreased in size 14 percent had grain drills and only 9 percent of the farms which made no change in size had this implement.

For other machines, particularly corn cultivators, there is apparently little relation between an increase in the size of the farm and their presence on the farm. This may indicate that certain machines are usually bought with the all-purpose tractors.

Table 13. — Relationship between the use of different tractor-operated machines and change in size of farms after the purchase of a tractor

Machine used	Change in size of farm					
	Increase in farm size		Decrease in farm size		No change in farm size	
	Farmers using machine	Farmers not using machine	Farmers using machine	Farmers not using machine	Farmers using machine	Farmers not using machine
	Percent	Percent	Percent	Percent	Percent	Percent
Grain drill	24	76	14	86	9	91
Grain combine	14	86	10	90	3	97
Corn planters	6	94	4	96	4	96
Corn cultivators	60	40	46	54	63	37
Corn pickers	19	81	14	86	16	84

Non-contiguous Farm Tracts

Almost one-third of the farmers using tractors had one or more farm tracts not immediately adjacent to their home farm. This represents an increase of 51 percent in the number of farmers operating such tracts since the time of purchasing the first tractor. Of the 183 farmers with non-contiguous tracts, 33 had 2 tracts and 15 had 3 or more. One farmer in the Red River Valley farmed on six non-contiguous tracts. In general, the farms in this area had more such units than farms in the other areas. This is to be expected, because this Valley is the most recently developed area and had more land available.

The non-contiguous tracts averaged 1.8 miles from the home farm. Although the majority of them were grouped about this distance, there were some exceptions. One operator in the Red River Valley operated a 240-acre tract a distance of 29.2 miles from his home farm. Very few of the farmers set up temporary headquarters on the non-contiguous tracts. Those who did usually had an extra set of buildings available and someone living at the farmstead. It is unlikely that farmers using horses exclusively would add much land unless the land were nearby.

Table 14. -- Tractor farmers with non-contiguous tracts and the number with temporary headquarters before tractor purchase and in 1938

Item	Area					
	South East	South Central	South West	West Central	Red River Valley	All Areas
	Number	Number	Number	Number	Number	Number
Farmers with non-contiguous tracts before purchase of tractor	9	12	29	34	36	120
Farms with non-contiguous tracts, 1938	14	19	37	50	63	183
Farms with one non-contiguous tract, 1938	9	14	34	40	38	135
Farms with two non-contiguous tracts, 1938	4	4	3	7	15	33
Farms with three or more non-contiguous tracts, 1938	1	1	0	3	10	15
Farms with temporary head-quarters, 1938	0	2	1	2	8	13

Table 15. -- Distance of non-contiguous tracts from home farm and acres per tract and total farm

Item	Unit	Area				
		South East	South Central	South West	West Central	Red River Valley
Average distance	Mile	1.6	1.5	2.0	1.3	3.0
Maximum distance	Mile	5.2	3.2	14.0	7.0	29.2
Average acres per tract	Acre	141	101	110	106	198
Average acres per farm with non-contiguous tracts	Acre	405	317	323	413	689

The trend on tractor farms toward the operation of larger farm units will probably continue for several years. About 20 percent of the farmers indicated that they were considering the acquisition of more land. These intentions varied from 12 percent indicating their wish to get more land in the older established agricultural areas of southern Minnesota to 35 percent in the Red River Valley. A few farmers would not consider 20 miles too far to go for additional tracts but most did not care to go beyond 2 miles. Those in the Red River Valley apparently would go farther than those in southern Minnesota.

Table 16. -- Opinion of tractor farmers regarding the feasibility of operating non-contiguous tracts, by areas 1/

Opinion	Area					
	South East	South Central	South West	West Central	Red River Valley	All Areas
	Number	Number	Number	Number	Number	Number
Not feasible	48	51	82	37	60	278
Feasible	20	33	78	102	69	302

1/ Based on 580 reports

Table 17. -- Maximum distance that farmers indicated they would travel to operate non-contiguous land, by areas

Distance (miles)	Area				
	South East	South Central	South West	West Central	Red River Valley
	Number	Number	Number	Number	Number
1 - 2	7	20	57	64	15
3 - 4	4	3	6	18	18
5 - 6	3	1	7	16	16
7 - 8		1	2		
9 - 10	1	1		3	11
11 - 12				1	1
13 - 14	1		1		
15 - 16					3
17 - 18					4

Less than one-third of the tractors were equipped with rubber tires. This varied from about one-fourth of the tractors in the West Central area to slightly over 40 percent in the South East and South West areas. The farmers who operated non-contiguous tracts had about 40 percent of the tractors with rubber tires, though these farmers represented only one-third of the farmers interviewed. About one-half of the farms with non-contiguous tracts had rubber-tired tractors. The South Central area had the largest proportion of such farms. Rubber tires facilitate travel on the roads to the non-contiguous tracts. This does not mean that the rubber tires are not worth while for field operations, but it appears that farmers have placed considerable importance on the ease of moving rubber-tired tractors on hard surface roads.

Table 18. -- Use of rubber-tired tractors on farms with non-contiguous tracts

Area	Rubber-tired tractors	
	Percent of all tractors	Percent of tractors on farms with non-contiguous tracts
South East	43	65
South Central	37	74
South West	42	51
West Central	26	42
Red River Valley	36	48
All Areas	31	51

Change in Horses and Mules on Tractor Farms

The number of horses and mules decreased on 87 percent of the farms after the purchase of a tractor. No change occurred on 10 percent of the farms and an increase occurred on only 3 percent of the farms.

The number of farms on which there was either an increase, or no change, in the work horse-and-mule numbers following the introduction of the first tractor was so small that, when combined with the farms on which there was a decrease in workstock numbers, a net decrease in work horse-and-mule numbers occurred for the entire group of farms for the period following the purchase of the first tractor until 1939, even though the entire group of farms was subdivided on the basis of the period when the first tractor was bought (table 20).

Table 19. -- Number and percentage of farms on which there had been a change in number of work horses and mules since the purchase of the first tractor, by areas

Area	Type of change in horse and mule numbers 1/							
	Increase			Decrease			No Change	
	Farms		Workstock	Farms		Workstock	Farms	
	Number	Percent	Number	Number	Percent	Number	Number	Percent
South East	3	5	2	51	82	4	8	13
South Central	2	2	3	59	70	3	23	28
South West	4	2	1	141	91	4	10	7
West Central	8	6	2	114	88	4	8	6
Red River Valley	2	2	8	105	93	7	6	5
Total	19	3	3	470	87	5	55	10

1/ Some farmers started with tractors and some rec rds were incomplete.

Table 20. — Average number of work horses and mules on tractor farms before purchase of first tractor in 1939, by areas

Area	Period when first tractor was bought															
	1923 or before				1924 - 1928				1929 - 1933				1934 - 1937			
	Number of farmers purchasing tractors	Work-stock per farm before tractor pur-chase	Work-stock per farm in 1939	Relative decrease in work-stock per farm	Number of farmers purchasing tractors	Work-stock per farm before tractor pur-chase	Work-stock per farm in 1939	Relative decrease in work-stock per farm	Number of farmers purchasing tractors	Work-stock per farm before tractor pur-chase	Work-stock per farm in 1939	Relative decrease in work-stock per farm	Number of farmers purchasing tractors	Work-stock per farm before tractor pur-chase	Work-stock per farm in 1939	Relative decrease in work-stock per farm
		Head	Head	Per-cent		Head	Head	Per-cent		Head	Head	Per-cent		Head	Head	Per-cent
South East	16	9.1	4.2	45	22	7.2	4.7	35	9	6.3	3.3	48	17	5.7	3.8	33
South Central	19	7.9	4.8	39	17	8.6	4.6	47	16	7.2	6.0	17	28	6.0	4.1	32
South West	12	8.8	4.8	46	27	9.2	4.2	54	40	7.8	4.4	44	73	7.1	3.8	47
West Central	20	10.0	3.4	66	25	7.4	3.6	51	23	7.3	3.7	49	52	6.8	4.0	41
Red River Valley	42	13.3	4.9	65	28	10.3	3.9	61	22	10.4	4.2	60	26	8.2	3.9	52

The decrease in numbers of work horses and mules per farm was both relatively and absolutely larger in the Red River Valley area for each period of tractor purchase than in any of the other areas. Generally speaking, the decline in workstock numbers was greater on tractor farms in the Southwest and West Central areas than on tractor farms in the South East and South Central areas. Farmers who bought tractors in the earlier periods decreased workstock numbers more than did farmers who bought in the later periods. This was partly because farmers who bought tractors in the earlier periods had larger farms, and consequently more horses and mules. These farmers also had more opportunity to complete the adjustments in the supply of farm power.

Data were not available to permit a careful comparison of the trend in workstock numbers on tractor farms and horse farms. From 1925 until 1938, however, the decline in horse-and-mule numbers for the State of Minnesota amounted to 20 percent. Comparing this figure with those presented in table 20 for the later three periods there is an indication that horse and mule numbers have decreased much more rapidly on tractor farms than on horse farms.

Changes in Labor Requirements on Tractor Farms

On the whole, there was no difference in the total amount of labor used on the farms after the purchase of a tractor compared with the total amount used previously, but the same amount of labor was handling more land. On about one-third of the farms, an average of 8 months less hired labor was used, and on 13 percent an average of about 9 months less family labor was used. On 18 percent an average of 7 months more hired labor was used, and on 19 percent, an average of 11 months more family labor was used. Hence in months of labor the net change is insignificant, being less than 1 percent for all farms studied.

The most significant change with respect to labor was the shortening of the farmers' work day. One-third of the farmers reported a shorter work day while only 5 percent indicated a longer work day. This varied somewhat by areas, apparently in accordance with the prevalence of seasonal work, like harvesting. The field day has apparently changed very little. About as many reported a shorter field day as reported a longer field day. Twenty-nine percent of the farmers shortened their field day approximately 1.7 hours per day, whereas 30 percent lengthened it 2.1 hours.

Table 21. -- Changes in labor used on tractor farms

Type of Labor	Increase in labor		Decrease in labor		No change in labor
	Percent of farms	Months	Percent of farms	Months	Percent of farms
	Percent	Number	Percent	Number	Percent
Hired	18	7	30	8	52
Family	19	11	13	9	68

Size of Farm and Power Requirements

The tractor must be large enough to perform the heavy work in a minimum of time and still do the other tractor work economically. A tractor may be used economically for light work such as raking hay, where this work constitutes a very small part of the total work and it is not found advisable to keep horses for these purposes. Because of the large number of light-draft jobs, and the large quantity of coarse roughage on many farms, it may be that a combination of horses and tractors provides the most economic source of power. The horses can be used for light jobs and a tractor for heavy work. Where two men are needed on the farm for the busy seasons, horses provide a flexible source of power, especially when the care of livestock does not take up the full time of one of the men. Horses are inflexible as far as feed costs are concerned, however, for they must be maintained whether they work or not.

Small tractors of about 10 or 12 horsepower were found on many farms of 180 acres or less. The average size of tractors, measured by drawbar rating, operated on farms up to 180 acres in size, was 12.6 horsepower. In addition to this power, an average of 3.1 horses were kept. For the farms averaging about 220 acres, the drawbar rating of tractors averaged 16.8 drawbar horsepower; on those averaging 270 acres the rating was 16.9 horsepower. In the South East and South Central Areas, a 15 horsepower tractor seems large enough for farms of about 200 crop acres, if supplemented with horses. In the other areas about 300 acres of cropland was handled with this amount of power. Where farms have more than this acreage of cropland, either two tractors or a larger tractor and more horses probably are required.

Horses furnished about 25 to 30 percent of the available farm power on tractor farms in 1938 regardless of the size of farm (table 22). In 1930, horses furnished about 50 percent of the power. 3/ As the size of farm increased and as more tractor drawbar power was available, the number of horses also increased.

The power available per farm for equivalent amounts of work was somewhat greater after the purchase of a tractor. Although definite replaceable equivalents of tractor power in terms of horses are difficult to determine because of the many tasks to be done on a farm, it is probable that more of the horses will be dispensed with eventually. Horses that die may not be replaced.

Evidence that farmers who use tractors depend generally upon both horses and tractors for their power needs, is the fact that only 19 farmers did not use horses and only 6 farmers kept only one horse. One hundred and thirty farmers or 23 percent kept two horses. This study indicates a wide variation in size of tractor and number of horses on farms of the same size in the same type of farming area, suggesting the necessity

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3/ Schwantes, A. J. and Pond, G. A. "The Farm Tractor in Minnesota". Minnesota Agricultural Experiment Station Bulletin 280, 1931. Page 19.

Table 22. -- Size of farms and drawbar power available, all areas

Item	Unit	Size of farms - acres							
		179 and below	180-259	260-339	340-419	420-499	500-579	580-659	660 & over
Number of farms	Number	108	109	114	43	28	19	17	143.0
Total cropland per farm	Acre	111	167	230	282	352	396	460	844.0
All land per farm	Acre	147	221	268	380	466	533	620	1185.0
Horses and mules per farm	Number	3.1	4.4	4.4	5.3	5.4	5.7	5.9	6.6
Tractor drawbar power per farm	H.P. 1/	12.60	16.76	16.88	18.34	20.96	26.86	24.34	42.0
Tractor drawbar power per farm	H.E. 2/	7.6	10.1	10.1	11.0	12.6	16.1	14.6	25.2
Total drawbar power per farm	H.E.	10.7	14.5	14.5	16.3	18.0	21.8	20.5	32.3

1/ H.P. computed on the basis of the rated drawbar horsepower of the tractors.

2/ H.E.= horse equivalent or .6 of tractor drawbar rating.

of each farmer deciding the size of tractor and number of horses that best fit his individual needs, for even farms within a community may require very different amounts and types of power.

Table 23. — Relationship between the number of horses and mules per farm, size of farm and total farm power

Item	Unit	Horses and mules per farm				
		2 or less	3-4	5-6	7-8	9 and over
Number of farms	Number	155	240	113	52	21
Total cropland per farm	Acre	219	225	257	292	570
All land per farm	Acre	294	306	345	388	758
Tractor drawbar power per farm	H.P 1/	15.7	16.7	18.2	18.1	29.5
Tractor drawbar power per farm	H.E.2/	9.4	10.1	10.9	10.9	17.7
Total drawbar power per farm	H.E.	11.1	13.4	16.3	18.4	29.4

1/ H.P. computed on the basis of the rated drawbar horsepower of the tractors.
2/ H. E. = horse equivalent or .6 of tractor drawbar rating.

The farmers who traded in their old tractors generally seemed to favor medium sized ones, or the ordinary two-plow size, when buying replacements. In no case was a tractor traded for one of a lower rated drawbar power. More than 75 percent of the farmers who replaced their tractors originally had small tractors of less than 15 drawbar horsepower. The farms operated averaged 382 acres and averaged 254 acres of cropland. In contrast, those farmers who had small tractors and traded for ones of a similar size operated farms averaging 199 acres of cropland. Of course, any individual farmer needs to buy the size of tractor most advantageous to him. It is possible that some farmers with approximately 250 acres of cropland would find it advantageous to buy a small tractor rather than a larger one, and vice versa. Other farmers would find two tractors more suitable for a farm of the same size if no horses were kept. A farmer may find that it would pay him to have a large tractor that will do many jobs quicker and allow him more time with his livestock, since livestock makes up a considerable part of the farm business on many farms.

Table 24. — Type of change that was made in size of tractor when first tractor was replaced, number of farmers making such a change, average rated drawbar horsepower of tractors on the farms in 1939, and average acres of cropland and total land in farms

Type of change in size of tractor 1/	Farmers making change	Rated drawbar power tractors on farms, 1939	Cropland per farm	Total land per farm
	Number	H.P.	Acres	Acres
Group I to I	13	10.4	199	346
I to II	36	16.0	254	382
I to III	5	21.7	168	271
II to II	3	15.4	128	422
II to III	11	21.9	256	420
II to IV	1	27.3	127	199
III to III	1	20.3	260	320

1/ Group I includes tractors with 5.5 - 11.99 horsepower; Group II 12.0 - 18.49; Group III 18.5 - 24.99; Group IV 25.0 to 31.49.

Those farmers who had more than one tractor were asked why they used more than the one (table 25). Fourteen indicated that they wanted an extra tractor for light work, and six that they had too few horses or had land in several scattered tracts. A few farmers had kept an old tractor because it was worth more for odd jobs on the farm than they could get by selling it.

Five farmers reported that they owned an extra tractor cooperatively with neighbors. Cooperative ownership of farm equipment may be an excellent method of providing machines that have limited use, or that involve large investments, without incurring the costs that are incident to the private ownership of them. Many expensive machines have been successfully owned and used in this way. As a tractor requires more care than most machines and involves more conflict with respect to use, all cooperative agreements need to be specific. Probably heavy belt work, plowing, and other jobs with heavy draft would be the operations where such an arrangement would be most useful. This would allow each of the cooperators to own a smaller tractor and probably operate it at its optimum capacity more frequently.

It seems safe to say that a tractor with a rating of 10 to 12 horsepower at the drawbar would be satisfactory for farms up to 180 acres, and even on farms with 200 crop acres, where horses are kept and providing no very heavy jobs are contemplated. Most farms had a team of horses in addition, though this may be unnecessary. A small tractor is also satisfactory where two tractors are operated on a single farm. The 15 to 18 horsepower tractor should be adequate for farms up to about 300 crop acres, especially where a few horses are kept to supplement the tractor for small jobs. It may be economical to have the extra power for relatively few jobs even though it is not used for most of the operations.

Table 25. -- Reasons given by farmers for owning more than one tractor, by areas

Item	Area				
	South East	South Central	South West	West Central	Red River Valley
	Number	Number	Number	Number	Number
Farmers reporting	10	18	20	16	48
Reasons given:	Frequency of reasons				
Heavy work	2	4	5	-	17
Combining and threshing	1	2	3	2	8
Belt work	3	4	4	-	2
Large acreage	3	1	7	8	8
Light work	1	1	2	2	8
Low value	1	3	1	-	4
Cooperatively owned or furnished	1	2	-	-	2
Short of horses	-	-	-	2	1
Land in several plots	-	-	-	3	-
Custom and special work	1	-	-	1	-

On specific farms of given sizes, the displacement of horses by tractors was greatest on the larger farms, although it tended to be about one horse for every 4 or 4.5 drawbar horsepower of the tractor on all farms except the small ones, -- those of less than 100 acres of cropland. This group (table 26), had an average displacement of 1 horse for every 5.8 tractor drawbar horsepower. While the conclusions drawn from table 26 are based on displacement of horsepower by tractor drawbar power for farm work, the entire displacement may not have taken place to date.

Table 26. -- Displacement of horses and mules, by tractors, by size of farm 1/

Cropland per farm	Farms	Average decrease in horses and mules	Tractor drawbar power added
Acres	Number	Number	H.P.
1 - 99	32	1.9	11.2
100 - 199	157	3.7	16.7
200 - 299	147	3.9	16.7
300 - 399	49	5.4	20.9
400 - 499	21	6.2	28.4
500 - over	23	9.3	39.8

1/ Size of farm measured by acres of cropland.

Changes in Crops and Livestock

The introduction of tractors on farms often initiates change in the crop and livestock enterprises. Many other factors, including the demand for and the supply of different farm products, the AAA and droughts, also affect these enterprises. The data available did not permit a complete analysis of the direct effect of tractors upon crop and livestock enterprises, because it was impossible to remove the effects of these other factors.

FINANCING METHODS

Some variation in methods of financing tractors was apparent in the several areas of the State. In the southern areas, most farmers paid cash or had tractors or machinery to trade-in on the new tractor. The greatest percentage of farmers paying cash and purchasing without pledging collateral was found in the South Central area. In the Red River Valley and West Central areas where crop production was relatively more important, more farmers gave promissory notes, chattel mortgages, time payments, or crop liens. Farmers in these areas reported nearly 50 percent of the tractors bought by means of chattel mortgages, time payments, or crop liens.

About 60 percent of the farmers reported trading-in various items when buying a new tractor. Two-thirds of these items were old tractors. Horses constituted the bulk of the remaining items.

Table 27. — Items traded-in on tractor purchases since 1925 and the number of farmers reporting each item, by areas

Item traded on purchase	Area					
	South East	South Central	South West	West Central	Red River Valley	All areas
	Number	Number	Number	Number	Number	Number
Tractors	29	28	46	67	52	222
Farm machinery	2	5	2	2	3	14
Trucks and automobiles	1	-	-	1	2	4
Horses	8	16	24	32	22	102
Other livestock	-	-	-	2	-	2
All items	40	49	72	104	79	344

SUMMARY

Tractor numbers have increased three-fold in Minnesota since 1925. During this same period, horse-and-mule numbers in the State have decreased 20 percent.

The study of 709 tractors on 581 farms in five of the major type-of-farming areas in Minnesota indicated that tractor farms were larger than other farms and, where increases in size were noted, the rate of increase was greater on tractor farms. Approximately one-fourth of the drawbar power on tractor farms was furnished by horses.

A displacement of horses and mules and a reduction of farm labor were associated with tractor use. The decrease in horse-and-mule numbers was greater on tractor farms than on all farms. The amount of labor used on tractor farms did not change appreciably after the purchase of the tractor but the same amount of labor was handling more land.

There has been an increase in the number of farmers who operate non-contiguous tracts since the purchase of the tractor. Part of this is due to the natural growth of farms in the period and part is associated with increased tractor use. About 20 percent of the interviewed farmers indicated that they were planning to increase the size of their farm units, and opinion was about evenly divided regarding the feasibility of using tracts several miles away from the home farm. As rubber-tired tractors are regarded as more important where travel on hard-surfaced roads is necessary, the increased adoption of rubber tires will probably encourage the farming of non-contiguous units.

Most of the interviewed farmers were using a combination of horses and tractors on their farms. More than 95 percent had two horses or more. Only 19 farmers out of the 581 did not keep horses. The drawbar horsepower of most of the tractors was between 10 and 18 horsepower. The small tractors of from 10 to 12 horsepower, when supplemented with horses, appeared to be adequate for farms up to 200 crop acres in size while the large ones of 15-18 drawbar horsepower seemed adequate for farms averaging 250 crop acres in southern Minnesota or 300 crop acres in the Red River Valley.

In general, farmers in southern Minnesota financed the purchase of new tractors by means of promissory notes, chattel mortgages, and time payments less frequently than did farmers in the Red River Valley, or in central Minnesota. Almost two-thirds of the farmers offering trade-ins on the purchase of a tractor gave tractors as part payment and the other one-third traded in horses.

APPENDIX

Table 28. — Distribution of tractor farms by size before purchase of a tractor and in 1938

Size in acres	Period when first tractor was purchased							
	Before 1925		1925-29		1930-34		1935-39	
	Before purchase of first tractor	1938	Before purchase of first tractor	1938	Before purchase of first tractor	1938	Before purchase of first tractor	1938
	Number	Number	Number	Number	Number	Number	Number	Number
Under 120	2	2	1	1	5	4	8	7
120 - 199	26	23	34	31	30	23	77	56
200 - 279	39	28	37	23	25	24	53	51
280 - 359	25	24	37	39	29	25	42	55
360 - 439	10	13	16	15	7	8	12	11
440 - 519	10	5	6	11	8	10	7	11
520 - 599	5	11	4	5	1	8	2	5
600 - 679	7	8	1	7		2	1	5
680 - 759		2			1	2	1	1
760 - 839		4	1	1				
840 - 919	1	1		1				1
920 - 999		1		1	1			
1000 and over	4	7	3	5	1	2		2
Total	129	129	140	140	108	108	203	203

Table 29. — Farm operations performed with tractors for selected years

Operations	1920		1925		1930		1935		1938	
	Farms report-ing	Work done	Farms report-ing	Work done	Farms report-ing	Work done	Farms report-ing	Work done	Farms report-ing	Work done
	Per-cent	Per-cent	Per-cent	Per-cent	Per-cent	Per-cent	Per-cent	Per-cent	Per-cent	Per-cent
					South East					
Fall Plowing	100	82	96	92	98	87	96	94	96	97
Discing	33	88	44	80	52	88	60	97	72	100
Spiketooth harrowing	8	100	16	81	28	81	49	85	69	88
Springtooth "	33	100	36	100	44	96	57	99	60	100
Field cultivating	8	100	16	100	22	100	21	100	27	100
Drilling small grain	—	—	—	—	4	100	9	97	16	100
Planting corn	—	—	—	—	2	100	2	100	6	100
Harrowing corn	—	—	3	100	7	100	9	100	27	97
Cultivating corn	—	—	—	—	9	100	21	98	65	85
Mowing hay	—	—	—	—	—	—	—	—	8	80
Hauling manure	—	—	—	—	2	100	4	75	19	58
Dumpraking hay	—	—	—	—	—	—	—	—	—	—
Side del. raking hay	—	—	—	—	—	—	—	—	6	68
Sweep raking	—	—	—	—	—	—	—	—	—	—
Stacking hay	—	—	—	—	—	—	—	—	—	—
Grain Harvesting	25	92	20	100	41	92	68	96	79	95
Combining	—	—	—	—	—	—	2	100	7	100
Corn picking	—	—	—	—	2	100	7	100	19	95
Corn binding	—	—	—	—	11	85	19	93	32	99
Potato planting	—	—	—	—	—	—	—	—	—	—
					South Central					
Fall plowing	92	80	95	81	94	84	97	90	99	95
Discing	46	93	52	83	54	87	62	93	73	95
Spiketooth harrowing	31	81	29	79	35	75	46	79	66	92
Springtooth harrowing	31	88	28	92	33	86	35	90	50	98
Field cultivating	8	100	5	100	19	100	25	100	26	97
Drilling small grain	—	—	5	100	6	67	5	83	10	94
Planting corn	—	—	5	100	—	—	—	—	4	96
Harrowing corn	8	100	5	100	2	100	2	100	6	100
Cultivating corn	8	100	10	100	10	92	20	89	62	93
Mowing hay	—	—	—	—	—	—	—	—	1	100
Hauling manure	—	—	—	—	2	50	9	38	20	51
Dumpraking hay	—	—	—	—	—	—	—	—	—	—
Side del. raking hay	—	—	—	—	—	—	—	—	5	45
Sweep raking	—	—	—	—	—	—	—	—	—	—
Stacking hay	—	—	—	—	—	—	—	—	—	—
Grain harvesting	54	100	48	100	65	95	82	96	89	97
Combining	—	—	—	—	—	—	—	—	5	100
Corn picking	—	—	14	100	17	94	25	97	41	98
Corn binding	8	25	10	38	13	79	25	89	33	94

Table 29. -- Farm operations performed with tractors for selected years (cont.)

Operations	1920		1925		1930		1935		1938	
	Farms reporting	Work done	Farms reporting	Work done	Farms reporting	Work done	Farms reporting	Work done	Farms reporting	Work done
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
					South West					
Fall plowing	80	90	93	88	93	98	92	98	98	99
Discing	40	98	47	79	83	92	88	98	98	99
Spiketooth harrowing	20	100	13	100	46	80	76	91	91	97
Springtooth harrowing	20	100	27	100	41	95	43	99	48	100
Field cultivating	--	--	--	--	5	100	7	100	13	100
Drilling small grain	--	--	--	--	5	67	11	100	32	99
Planting corn	--	--	--	--	--	--	2	100	5	95
Harrowing corn	10	100	7	100	19	91	43	95	62	100
Cultivating corn	--	--	--	--	7	98	39	92	83	94
Mowing hay	--	--	--	--	--	--	2	100	10	87
Hauling manure	--	--	--	--	--	--	1	50	16	73
Dumpraking hay	--	--	--	--	--	--	--	--	1	100
Side del. raking hay	--	--	--	--	--	--	--	--	1	88
Sweep raking	--	--	--	--	--	--	--	--	1	100
Stacking hay	--	--	--	--	--	--	--	--	1	100
Grain harvesting	10	100	20	70	46	92	79	99	94	99
Corn picking	--	--	--	--	19	88	25	100	34	100
Combining	--	--	--	--	--	--	1	100	1	100
Corn binding	--	--	--	--	--	--	57	100	14	98
Potato planting	--	--	--	--	--	--	--	--	2	100
Potato digging	--	--	--	--	--	--	--	--	0	100
					West Central					
Fall plowing	100	80	93	82	95	91	98	97	97	98
Discing	67	79	73	75	86	91	89	97	96	99
Spiketooth harrowing	28	70	40	68	58	82	67	89	91	94
Springtooth harrowing	11	100	10	100	14	100	23	100	23	100
Field cultivating	--	--	7	100	12	100	12	100	11	100
Drilling small grain	--	--	3	100	14	100	33	98	60	98
Planting corn	--	--	--	--	3	100	5	100	9	99
Harrowing corn	17	83	23	72	29	91	31	95	63	98
Cultivating corn	--	--	3	100	17	97	30	93	78	95
Mowing hay	--	--	--	--	3	100	4	100	14	88
Hauling manure	--	--	--	--	2	100	3	83	28	64
Dumpraking	--	--	--	--	2	100	2	100	5	88
Side del. raking hay	--	--	--	--	--	--	1	100	3	100
Sweep raking hay	--	--	--	--	2	100	1	100	3	100
Stacking hay	--	--	--	--	--	--	2	100	5	100
Grain harvesting	50	83	40	81	66	93	88	97	94	99
Combining	--	--	--	--	3	100	3	100	3	100
Corn picking	17	100	13	100	14	100	23	100	40	95
Corn binding	--	--	3	100	5	100	14	96	30	96
Potato planting	--	--	--	--	--	--	--	--	--	--
Potato digging	--	--	--	--	--	--	1	100	3	100

Table 29. -- Farm operations performed with tractors for selected years (cont.)

Operations	1920		1925		1930		1935		1938	
	Farms reporting	Work done	Farms reporting	Work done	Farms reporting	Work done	Farms reporting	Work done	Farms reporting	Work done
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
					Red River Valley					
Fall plowing	95	74	96	71	96	84	97	94	100	97
Discing	35	74	43	81	51	92	68	93	77	99
Spiketooth harrowing	16	85	26	58	40	76	72	81	87	91
Springtooth harrowing	27	78	26	85	37	90	42	93	43	99
Field cultivating	14	90	19	79	24	93	33	95	42	100
Drilling small grain	14	65	9	69	24	82	54	91	78	96
Planting corn	--	--	2	100	1	100	5	100	8	100
Harrowing corn	--	--	--	--	2	75	16	98	20	96
Cultivating corn	--	--	--	--	1	100	11	87	19	97
Mowing hay	--	--	--	--	1	100	6	90	16	93
Hauling manure	--	--	--	--	2	100	4	84	9	83
Dumpraking	--	--	--	--	--	--	--	--	2	100
Side del. raking hay	--	--	--	--	--	--	1	100	3	100
Sweep raking hay	--	--	--	--	1	100	1	100	7	100
Stacking hay	--	--	--	--	--	--	1	100	2	100
Grain harvesting	22	75	26	76	51	82	75	91	85	97
Combining	--	--	--	--	4	100	11	95	30	100
Corn picking	--	--	--	--	--	--	--	--	--	--
Corn binding	--	--	--	--	6	80	14	85	25	99
Potato planting	--	--	--	--	4	75	8	93	18	100
Potato digging	8	83	4	100	5	100	16	91	26	99
					All Areas					
Farm plowing	95	79	95	80	95	89	96	95	99	98
Spring plowing	58	81	57	84	57	91	55	96	58	98
Discing	43	82	51	78	65	69	76	96	86	98
Spiketooth harrowing	20	82	26	70	42	79	65	90	84	93
Springtooth "	24	88	25	93	33	93	39	96	43	99
Field cultivating	8	93	12	88	17	97	19	98	22	99
Drilling small grain	6	65	4	63	12	85	26	94	44	97
Planting corn	--	--	1	100	1	100	3	100	7	98
Harrowing corn	6	90	8	83	12	91	22	95	41	98
Cultivating corn	1	100	2	100	8	96	23	92	63	93
Mowing hay	--	--	--	--	1	100	6	96	10	89
Hauling manure	--	--	--	--	2	90	3	82	18	65
Dumpraking	--	--	--	--	--	100	1	88	2	93
Side del. raking hay	--	--	--	--	--	--	1	100	3	79
Sweep raking	--	--	--	--	1	100	1	100	3	100
Stacking hay	--	--	--	--	--	--	1	100	1	100
Grain harvesting	31	87	30	86	54	90	59	96	90	98
Combining	--	--	--	--	2	100	4	97	9	100
Corn picking	3	100	5	100	9	93	16	99	27	97
Corn binding	1	25	2	58	3	88	10	93	25	97
Potato planting	2	100	--	--	3	81	2	94	5	100
Potato digging	3	125	2	100	1	100	5	93	8	99